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(54) Improved process for the production of perfluoropolyethers substantially comprising perfluorooxyethylene and perfluorooxypropylene units.

(57) Improved process for producing perfluoropolyethers predominantly composed of units of formulae
$-CF_2CF_2O-$
and

$$-CF_2\underset{\displaystyle CF_3}{\underset{|}{C}}FO-$$

and terminal perfluoroalkyl groups, with a ratio of the above C_3/C_2 units within the range of from 0.2 to 6, showing a good combination of chemical and physical properties, comprising the photo-oxidation of C_3F_6 and C_2F_4 under controlled conditions.

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IMPROVED PROCESS FOR THE PRODUCTION OF PERFLUOROPOLYETHERS SUBSTANTIALLY COMPRISING PERFLUOROOXYETHYLENE AND PERFLUOROOXYPROPYLENE UNITS

The present invention relates to the production of perfluoropolyethers predominantly composed of units of the formulae
$-CF_2CF_2O-$
and

$$-CF_2\underset{\underset{CF_3}{|}}{C}FO-$$

and terminal perfluoroalkyl groups,which products show an optimum combination of chemical and physical properties.

The process for producing said perfluoropolyethers is based on the low-temperature photo-oxidation of a mixture of perfluoropropene and tetrafluoroethylene, the subsequent decomposition of the peroxide groups contained in the resulting products and the fluorination of the end groups in order to convert them to perfluoroalkyl groups, and the optional regulation of the molecular weight in case the latter is too high for the intended use of the end product.

The various steps of the present process are based on wellknown techniques. However, the products obtained according to the present invention are the result of the application of specific working conditions which allow to prepare them at economically favourable costs and with high yields with respect to the starting perfluoroolefins.

The photo-oxidation of C_2F_4/C_3F_6 mixtures is known from USA 3,442,942; 3,665,041 and 3,770,792 as well as from DE-A-18 17 826.

In said publications the specific operating conditions which, according to the present invention, are essential for obtaining the above products in high yields and high conversions with respect to the perfluoroolefins used as the starting material have not been taken into consideration. Particularly, the products disclosed in the examples of the above publications show a rather low ratio of C_2 to C_3 units.

According to the present invention, by adopting specific working conditions in the photo-oxidation of the C_2F_4 C_3F_6 mixture and by subsequent decomposition of the peroxy groups and conversion of the terminal groups to perfluoroalkyl end groups by means of special methods, perfluoropolyethers may be obtained, which have the general formula:

$$R_fO(CF_2CF_2O)_m\left(CF_2-\underset{\underset{CF_3}{|}}{C}FO\right)_n(CF_2O)_p\left(\underset{\underset{CF_3}{|}}{C}FO\right)_q R'_f$$

wherein:

R_f and R'_f, the same or different from each other, are terminal perfluoroalkyl groups selected from: $-CF_3$, $-C_2F_5$ and $-C_3F_7$; and

m,n,p and q which represent average values for the products which are generally composed of mixtures of individual compounds within the scope of the above formula, meet the following conditions:

- the sum $(m+n+p+q)$ is within the range of from 2 to 200;
- the ratio $(p+q)/(m+n+p+q)$ is smaller than or equal to 10/100, and preferably ranges from 0.5/100 to 4/100;
- th ratio n/m is in the range of from 0.2 to 6, and preferably of from 0.5 to 3.

m, n, p and q are the same or different from each other. Both m and n preferably range from 1 to 100 (most preferred from 1 to 80) whereas both p and q preferably range from 0 to 80 (most preferred from 0 to 50).

As compared to the products known from the prior art, the products obtainable according to the present invention are characterized by the following properties:

- a very low content of $-CF_2O-$ units, which are known to constitute breakage points of the perfluoropolyether chain: as a consequence, they have a high stability to catalytic breakdown;
- a high value of the ratio n/m, which involves a higher content of C_3 units, and a decidedly lower viscosity, with the molecular weight being the same; therefore the products have a low viscosity also at very low temperatures, and at the same time have an extremely low vapour pressure due to their high molecular weight; furthermore, their pour point is lower, with the molecular weight being the same, which means that low-pour-point, low-volatility products are available through the process of the present invention.

Furthermore, with the process according to the present invention it is unexpectedly possible to obtain C_2F_4 conversions which are much higher than those of the prior art, and are generally of the order of 90%.

Particularly, it can be observed that the products according to the present invention, as compared to the perfluoropolyethers obtained by means of the photooxidation of only C_2F_4 alone (and thus not containing C_3 units, e.g. Fomblin -® Z), show a much smaller content of $-CF_2O-$ groups, and therefore a much higher stability.

Furthermore, the present process is easier to carry out from a technical point of view and less expensive in that it does not require the use of solvents, which are needed, on the contrary, in the case of photo-oxidation of only C_2F_4

From US-A-3,770,792 to Sianesi, it is known to prepare PFPE products containing both $-CF_2CF_2O-$ and $-CF(CF_3)CF_2O-$ units by means of the simultaneous photochemical oxidation of C_2F_4 and C_3F_6. Under the operating conditions stated or suggested in the above patent and in particular, in the examples thereof, very high conversions and yields of useful products cannot be obtained, however. The highest yields given in the examples are 70% based on C_2F_4 and 60% based on C_3F_6, while the maximum conversions are 60% for C_2F_4 and 15% for C_3F_6.

In particular, as regards the U.V. light, which is a key factor of the process, the above patent suggests to work under conditions such that the irradiation index I, as defined below, is at least 2, and preferably at least 3, and up to 50 in order to obtain a product not containing an excessively large amount of peroxy oxygen. Said index is represented by the formula:

$$I = \frac{100 \cdot E}{S^{\frac{1}{2}} \cdot V^{\frac{1}{3}}} \quad (\mathrm{watt/cm^2})$$

wherein:
E = U.V. energy at a wavelength of ≤330 nm in watts,
S = the surface area through which the energy E penetrates the system, in cm^2, and
V = the volume, in cm^3, of the reaction system.

From the examples reported in the patent values of I of around 6 may be calculated; in example 9 it is shown that a low value of I (1.4) results in a high content of peroxy oxygen.

It has now surprisingly been found that compared to the results reported in the above patent yields and conversions can considerably be improved and that yields of more than 90% based on C_2F_4 and contemporaneously of approximately 90% based on C_3F_6 and conversions higher than 60% for C_2F_4 and of the order of 15%, and even higher, for C_3F_6, can be achieved.

These results may be obtained by adopting optimum working conditions, which are characterized, in particular, by specific values of the U.V. light intensity with respect to the volume of the liquid reaction phase and the flow rate of the gaseous reactants (O_2, C_2F_4, C_3F_6) which are fed as continuous stream.

As regards the radiation energy E suitable for the photochemical effects in the reaction, said energy corresponding to radiation having a wavelength of ≤300 nm, it was found that the intensity of said radiation, with respect to both the volume of the liquid reaction phase (V_{liq}) and the flow rate (F_g)of the continuously fed gaseous reactants (O_2, C_2F_4, and, possibly, C_3F_6) must meet the following conditions:
a) $E{:}V_{liq}$ is within the range of from 15 to 150, and preferably of from 20 to 100, E being expressed in watts and V_{liq} being expressed in dm^3;
b) $E{:}F_g$ ranges from 0.15 to 1.55, F_g being expressed as litres/hour (1/h) of $C_2F_4 + O_2(+C_3F_6)$.

Another important parameter is the value of the gas flow rate F_g with respect to the volume of the liquid phase of the reaction (V_{liq}): said value is interdependent with the above paramet rs (a) and (b), and should be such that:
c) V_{liq}/F_g is from 10.10^{-3} to 25.10^{-3}, and preferably from 10.10^{-3} to 17.10^{-3}.

It is evident that the operating conditions of the process according to the present invention are

considerably different from those of the process disclosed and exemplified by the above US patent, due to a considerably higher intensity of radiation with respect to the reaction volume (liquid phase) and the flow rate of the gaseous reactants. Furthermore, the flow rate of the gaseous reactants with respect to the reaction volume (liquid phase) is maintained at lower values.

It was not foreseeable that by employing a specific radiation intensity with respect to both the volume of the reactant liquid phase and the flow rate of the gaseous reactants, which is much higher than the ones generally used in the processes of the prior art, not only the conversions but also the yields of useful products can be improved substantially.

The liquid reaction phase, contained in the reactor, is exposed to U.V. radiation emitted by a lamp of known type, with a wavelength within the range of from 200 to 600 nm.

The other operating conditions of the process according to the present invention fall within the scope of the processes known from the above patent to Sianesi and still other patents of the applicant.

The reaction is carried out at a temperature of from -30 to -100°C by passing the gaseous reactants O_2 and C_2F_4 and possibly also C_3F_6, through the reaction liquid initially composed of only liquified C_3F_6 and, subsequently of a mixture of said C_3F_6 and the liquid products formed during the reaction.

The gaseous mixture of $O_2 + C_2F_4$ is introduced continuously. and the molar ratio of O_2/C_2F_4 is kept within the range of from 1 to 10, preferably of from 3 to 9.

The reactant mixture is maintained at a temperature of from -30°C to -100°C, preferably of from −40 to -80°C.

The reaction can be carried out under atmospheric, subatmospheric and superatmospheric pressures. The product of the photo-oxidation, containing peroxy groups and having a very high molecular weight (i.e., a high viscosity) in consideration of the usual applications of the end product, is subjected to a thermal or photochemical treatment for the elimination of the peroxy groups according to methods known from, e.g., GB-A 1,226,566. The fluorination of the end groups is (then) carried out with fluorine gas thermally at temperatures of from 100° to 250°C or in the presence of U.V. light at temperatures of from 50° to 120°C, see US-A-4,664,766.

The liquid reaction phase, contained in the reactor, is exposed to U.V. radiation emitted by a lamp of known type, with a wavelength within the range of from 200 to 600 nm.

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The thermal decomposition of the peroxide groups may be only partial, the residual peroxy oxygen being eliminated during the subsequent fluorination step (see US-A-4,664,766), a controlled reduction of the molecular weight being thus achieved, as disclosed in US-A-4,668,357.

The regulation of the molecular weight can be further accomplished by means of a catalytic thermal cracking treatment at a temperature of from 150° to 380°C, in the presence of AlF_3 or any other catalytically active fluorides, oxyfluorides or oxides, as disclosed in EP-A 167,258, 224,201 and 223,238, followed by the fluorination with fluorine gas as described above in order to convert the oxygen-containing terminal groups into neutral perfluoroalkyl groups.

The catalytic thermal cracking treatment furthermore decreases the content of $-CF_2O-$ units present in the product, whereby an end product which contains a minimum number of such units can be obtained.

The peroxy product from the photo-oxidation can optionally be directly subjected to the above catalytic thermal cracking treatment.

The following examples are given only for illustrative purposes.

Example 1

At a temperature of -60° C, 800 g of C_3F_6 were placed into a cylindrical glass reactor (volume 500 ml, optical path 1 cm), equipped with an internal coaxial quartz sheath, a dipping tube for the introduction of gases, a sheath with a thermocouple for determining the internal temperature and a reflux condenser maintained at a temperature of -80° C. Through the dipping tube a gaseous mixture consisting of 27 l/h of O_2 and 9 l/h of C_2F_4 was introduced in the reactor. By means of a cooling bath placed around the reactor the temperature of the liquid reactant phase was maintained at -60° C throughout the whole experiment.

After introducing an U.V.-lamp (HANAU TQ 150 type; emitting 47 W of U.V. light having a wavelength in the range of from 200 to 600 nm and 12 W of energy corresponding to radiation of ≤300 nm)into the quartz sheath, said lamp was turned on, and irradiation and introduction of the reactant gases were continued for 5 hours.

After 5 hours of irradiation, the lamp was turned off, the reactor was vented, and from the reactor the unreacted C_3F_6 was recovered by evaporation at room temperature. Thus 420 g of oily polymeric residue were obtained. Said residue had a content of active (peroxy) oxygen of 2.75%, based on iodometric titration. The ^{19}F-NMR spectrum revealed polyetherpolyperoxy chains, wherein the total C_3F_6/C_2F_4 ratio was 0.85 and the ratio $CF_2/C_3F_6+C_2F_4$ was 0.019. The average number molecular weight was 6,630 and the viscosity of the product was 983 cSt at 20° C, as determined with an OSTWALD-FENSKE viscometer. The yield with respect to C_2F_4 in the obtained oil was 93%.
The results of Examples 1-8 are summarized in Table 1.

Example 2

By using the same equipment as in Example 1, a photooxidation was carried out under the same conditions, as regards temperature and intensity of irradiation, as in Example 1, but the flow rate of C_2F_4 was changed. In this case, 3 l/h of TFE were employed. After 5 hours of reaction, 213 g of a polymer with a content of active oxygen of 0.7% (based on iodometric titration) were isolated from the reactor . According to ^{19}F-NMR the polymer was composed of polyether-polyperoxy chains, wherein the ratio C_3F_6/C_3F_4 was 2.11, the ratio $CF_2/C_3F_6+C_2F_4$ was 0.063, and the average number molecular weight was 5,700.
The viscosity of the product was 955 cSt at 20° C.

Example 3

By using the same equipment as in Example 1, a photooxidation was carried out under the same conditions of temperature, flow rate of O_2 and flow rate of C_2F_4 as in Example 2, but the intensity of the lamp was reduced. In this case 33W of U.V. radiation within the range of from 200 to 600 nm and 8.5 W of U.V. radiation of ≤300 nm were used.

After 5 hours of reaction, 147 g of a polymer were recovered from the reactor, which polymer, as revealed by ^{19}F-NMR,was composed of polyether-polyperoxy chains wherein the ratio C_3F_6/C_2F_4 was 0.74, the ratio $CF_2/C_3F_6+C_2F_4$ was 0.0112, and the average number molecular weight was 12,000.
According to iodometric analysis, the product had a content of active oxygen of 3.86% and showed a viscosity of 5,330 cSt at 20° C.

Example 4

By using the same equipment as in Example 1, a photooxidation was carried out under the same conditions of temperature and intensity of irradiation as in Example 1, but the flow rate of the reactants was changed. In this case, 5 l/h of C_2F_4 and 31 l/h of O_2 were introduced. After 5 hours of reaction, 338 g of a polymer were recovered from the reactor. According to iodometric analysis, said polymer showed a content of active oxygen of 1.9%.
The viscosity of the product was 637 cSt at 20° C.

The ^{19}F-NMR analysis showed that the polymer was composed of polyether-polyperoxy chains wherein the ratio C_3F_6/C_2F_4 was 1.18, the ratio $CF_2/C_3F_6+C_2F_4$ was 0.027, and the average number molecular weight was 5,200.

Example 5

By using the same equipment as in Example 1, a photooxidation was carried out under the same conditions as in Example 1, but at a temperature of -40 °C. In this case, after 5 hours of reaction, 488 g of a polymer were recovered from the reactor. According to iodometric analysis, said polymer showed a content of active oxygen of 1.9%.

The viscosity of the product was 210 cSt at 20 °C.

^{19}F-NMR analysis showed the polymer to be composed of polyether-polyperoxy chains wherein the ratio C_3F_6/C_2F_4 was 1.17, the ratio $CF_2/C_3F_6+C_2F_4$ was 0.032, and the average number molecular weight was 3,000.

The yield of C_2F_4 in the obtained oil was 89%.

Example 6

By using the same equipment as in Example 1, a photooxidation was carried out under the same conditions as in Example 2, but at a temperature of -40 °C. After 5 hours of reaction, 479 g of a polymer were isolated from the reactor. According to iodometric analysis, said polymer showed a content of active oxygen of 0.92%.

The viscosity of the product was 188 cSt at 20 °C.

The ^{19}-NMR analysis showed the polymer to be composed of polyether-polyperoxy chains wherein the ratio C_3F_6/C_2F_4 was 1.91, the ratio $CF_2/C_3F_6+C_2F_4$ was 0.038, and the average number molecular weight was 3,300.

Example 7

By using the same equipment as in Example 1, a photooxidation was carried out under the same conditions as in Example 3, but at a temperature of -40 °C.

The radiation energy at a wavelength of ≤300 nm was 8.5 W.

After 5 hours of reaction, 265 g of a polymer were recovered from the reactor. According to iodometric analysis the polymer had a content of active oxygen of 1.47%.

The viscosity of the product was 504 cSt at 20 °C.

^{19}F-NMR analysis showed the polymer to be composed of polyether-polyperoxy chains wherein the ratio C_3F_6/C_2F_4 was 1.47, the ratio $CF_2/C_3F_6+C_2F_4$ was 0.021, and the average number molecular weight was 4,200.

Example 8

By using the same equipment as in Example 1, a photooxidation was carried out under the same conditions as in Example 4, but at a temperature of -40 °C.

After 5 hours of reaction, 453 g of a polymer were discharged from the reactor. According to the iodometric analysis the polymer had a content of active oxygen of 1.26%.

The viscosity of the product was 226 cSt at 20 °C.

^{19}F-NMR analysis showed the polymer to be composed of polyether-polyperoxy chains, wherein the ratio C_3F_6/C_2F_4 was 0.024, and the average number molecular weight was 3,400.

Example 9

A stainless-steel cylindrical reactor was used, which reactor was equipped with a coaxial quartz sheath. The ratio E/V_{liq} was 80, the ratio E/F_g was 0.88, and the ratio V_{liq}/F_g was 11×10^{-3}.
The reaction was started with an initial charge of liquid C_3F_6 in th reactor. During the reaction, a flow rate of the reactant gases was maintained which was 2,730 l/h for O_2 and 1,344 l/h for C_2F_4.
The reaction was carried out for 42 hours. The reaction product was continuously discharged, and C_3F_6 was replenished in a way such as to maintain a constant concentration of the oil in the reactor.

The relevant operating conditions are reported in Table 1. In the same table, the data reported in the Examples of the above cited US-A-3,770,792 are given for comparative purposes.

Example 10

The product obtained in Example 4 was placed in a photochemical reactor and was subjected to a photoreduction at a temperature of 40 °C in order to eliminate the peroxy power (P.O.). After 12 hours, 321 g of polymer were discharged, placed into a photochemical reactor and subjected to a photo-assisted fluorination at a temperature of 50 °C (5 l/h of fluorine and 5 l/h of nitrogen). After 10 hours, 314 g of neutral product were obtained (yield 95%). By distillation of the neutral product under vacuum four fractions, A, B, C and D, were obtained, which showed the characteristics reported in Table 2.
The ratios C_3F_6O/C_2F_4O were, respectively:
for A = 1.13; for B = 1.42; for C = 1.32; for D = 1.20; the ratios C_3F_6O/CF_2O were:
for A = 14.2; for B = 15.5; for C = 14.0; for D = 11.9; the ratios C_2F_4O/CF_2O were:
for A = 12.5; for B = 10.9; for C = 10.2; for D = 9.8.
From this data, one can calculate the ratio:

$$\frac{CF_2O}{C_3F_6O+C_2F_4O}$$

which was:
for A = 3.74%; for B = 3.79%; for C = 4.22%;and for D = 4.64%.

In Table 3 the characteristics of Fomblin ® Y and Z (commercial products) are given for comparative purposes.

Table 1

Example	Temperature °C	C_3F_6 g	Flow rate l/h O_2	Flow rate l/h C_2F_4	Time, h	Produced oil, g	Average Molecular Weight	Peroxy Power (P.O.)	Ratio C_3/C_2
1	-60	800	27	9	5	420	6,636	2.75	0.85
2	-60	800	27	3	5	213	5,700	0.7	2.11
3	-60	800	27	3	5	147	12,000	3.86	0.74
4	-60	800	31	5	5	338	5,200	1.9	1.18
5	-40	800	27	9	5	448	3,000	1.74	1.17
6	-40	800	27	3	5	279	3,300	0.92	1.91
7	-40	800	27	3	5	165	4,200	2.1	1.47
8	-40	800	31	5	5	453	3,400	1.26	1.83
9	-60	449,000	2,730	1,344	42	798,000	4,000	1.05	1.1
US-A-3,770,792									
Example 2	-50	700	40	20	2	198	10,000	2.2	0.83
Example 3	-50	700	80	20	2	220	12,000	3.2	0.58
Example 5	-40	700	40	20	2	158	8,000	0.95	0.53
Example 9	-40	700	40	20	2	26	15,000	5.00	0.82

(cont'd) Table 1

Example	Recovery, g		Yield, %		Conversion, %		E/V_{liq}	E/F_g	$V_{liq}/F_g.10^3$
	C_2F_4	C_3F_6	C_2	C_3	C_2	C_3			
1	34	585.8	98	97	81.7	26.7	24	0.33	13.88
2	19.9	642.8	97	92	68.2	18.0	24	0.4	16.66
3	0	725	92	90	91.2	8.5	16.8	0.28	16.66
4	0	590	97.5	90	97.5	23.7	24	0.33	13.88
5	37.3	497	96	91	78.5	34.5	24	0.33	13.88
6	0	593	96	90	95.8	23	24	0.4	16.66
7	19.1	689.4	93	91	66.5	12.3	16.8	0.28	16.66
8	0	483.3	97	93	96.7	36.2	24	0.33	13.88
9	3,000	6,000	96	90	95	88	80	0.88	11
US-A-3,770,792									
Example 2	30	545	58	61	43.2	13.8	7.76	0.056	7.3
Example 3	28	490	69	43	57.9	12.9	7.76	0.034	4.38
Example 5	33	510	53	32	43.3	8.7	7.76	0.056	7.3
Example 9	-	-	-	-	6	2	2.05	0.015	7.3

NOTE: In Example 9, the amount of C_3F_6 corresponds to the initial charge, plus the periodic additions of C_3F_6.

Table 2

PROPERTY	PFPE			
	A	B	C	D
Molecular weight	1,900	3,200	4,000	6,200
Kinematic viscosity (20 °C, cSt)	29	124	247	900
Viscosity Index	103	137	145	190
Pour Point (°C)	-62	-44	-38	-33
Density (20 °C, g/ml)	1.85	1.86	1.86	1.87
Refractive index (n_D^{20})	1.289	1.295	1.297	1.298
Surface tension, (dyne/cm)	22	23	22	24
Volatility, (149 °C, 22 hv) WE/LON	16.4	0.9	0.3	0.1
Tg (°C)	-93.5	-86	-81	-77
Vapour pressure at 20 °C (torr)	$2.7x10^{-5}$	$7.9x10^{-8}$	$-3.7x10^{-8}$	$-9.1x10^{-11}$

Table 3

PROPERTY	Series Y PFPE					Series Z PFP		
Molecular weight	1,800	2,500	3,300	4,100	6,600	3,900	7,850	9,400
Kinematic viscosity (20 °C,cSt)	60	140	270	450	1,350	29.2	148	255
Viscosity Index	70	-	108	117	130	317	320	355
Pour Point (°C)	-50	-45	-35	-30	-20	-90	-80	-66
Density (20 °C, g/ml)	1.88	1.89	1.900	1.902	1.913	1.824	1.841	1.851
Refractive index (n_D^{20}.)	1.295	1.296	1.300	1.301	1.302	1.290	1.293	1.294
Surface tension (dyne/cm)	21	22	22	23	24	23	24	25
Volatility (149 °C, 22 hv) WE/LON	5	5	5	5	1	7.3	0.7	0.03
Vapour pressure at 20 °C (torr)						-	$1.6x10^{-6}$	$2.9x10^{-12}$

Claims

1. Process for preparing perfluoropolyethers having the general formula:

$$R_fO(CF_2CF_2O)_m \left(CF_2-\underset{\substack{|\\ CF_3}}{C}FO\right)_n (CF_2O)_p \left(\underset{\substack{|\\ CF_3}}{C}FO\right)_q R'_f$$

wherein:
R_f and R'_f, the same or different from each other, are perfluoroalkyl end groups selected from $-CF_3$, $-C_2F_5$, and $-C_3F_7$; and
m,n,p and g which represent average values for the above products satisfy the following conditions:
- the sum (m+n+p+q) ranges from 2 to 200;
the ratio (p+q)/(m+n+p+q) is smaller than or equal to 1/10;
- the ratio n/m ranges from 0.2 to 6; comprising the following steps:
a) photo-oxidation of a mixture of C_3F_6 and C_2F_4, carried out by passing a gaseous stream of O_2 and C_2F_4, in a molar ratio of from 1 to 10, through a liquid reaction phase initially composed of C_3F_6 and maintained at a temperature of from -30 °C to -100 °C, while irradiating with UV light;
b) thermal or photochemical treatment of the photo-oxidation product in order to totally or partially eliminate the peroxy groups;

c) fluorination with fluorine gas at a temperature of from 100 to 250 °C or in the presence of U.V. light at 50 to 120 °C, in order to convert the end groups into perfluoroalkyl groups and to eliminate any peroxy groups which might possibly still be present;
said process being characterized in that the intensity of the radiation used in step (a), expressed as energy E (in W) emitted in the form of radiation of $\lambda \leq 300$ nm, the volume of the liquid reaction phase V_{liq} (in dm^3 and the flow rate of the reactant gases Fg (in l/h), meet the following conditions: rate of the reactant gases F_g (in 1/h), meet the following conditions:

E/V_{liq}	ranges from 15 to 150;
E/F_g	ranges from 0.15 to 1.55;
V_{liq}/F_g	ranges from 10.10^{-3} to 25.10^{-3}.

2. Process for preparing perfluoropolyethers according to claim 1, wherein steps (b) and (c) are carried out simultaneously.

3. Process according to claim 1 or 2, additionally comprising a molecular weight regulation by means of a catalytic thermal cracking treatment, carried out at 150 to 380 °c in the presence of AlF_3 or any other fluorides, oxyfluorides or oxides with catalytic activity, followed by the fluorination with fluorine gas in order to convert the terminal groups to perfluoroalkyl groups.

4. Process according to any one of claims 1 to 3, wherein the peroxy product from the photo-oxidation step (a) is directly subjected to the catalytic thermal cracking treatment.

5. Perfluoropolyethers, obtainable according to the process of any one of claims 1 to 4.

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(54) Improved process for the production of perfluoropolyethers substantially comprising perfluorooxyethylene and perfluorooxypropylene units.

(57) Improved process for producing perfluoropolyethers predominantly composed of units of formulae
$-CF_2CF_2O-$
and

$$-CF_2\underset{\displaystyle CF_3}{\underset{|}{C}}FO-$$

and terminal perfluoroalkyl groups, with a ratio of the above C_3/C_2 units within the range of from 0.2 to 6, showing a good combination of chemical and physical properties, comprising the photo-oxidation of C_3F_6 and C_2F_4 under controlled conditions.

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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D,X	FR-A-1 585 601 (MONTECATINI EDISON S.P.A.) * Example 10; claims * -----	1-5	C 08 G 65/00
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			C 08 G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27-03-1990	WEIS R.E.

CATEGORY OF CITED DOCUMENTS

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